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# I BELIEVE IN GOD AND IN EVOLUTION

BY  
WILLIAM W. KEEN, M.D.

EMERITUS PROFESSOR OF SURGERY,  
JEFFERSON MEDICAL COLLEGE, PHILADELPHIA

*SECOND EDITION*



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TO ALL SINCERE SEEKERS AFTER TRUTH;  
WHO REVERE THE BIBLE AS THE WORD  
OF GOD; WHO REVERE NATURE AS THE  
WORK OF GOD; AND WHO BELIEVE THAT  
RIGHTLY INTERPRETED THEY MUST  
SURELY AGREE.



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## **PREFACE TO THE SECOND EDITION**

A new edition enables me, in Section X, to explain a defective embryonic development in the neck which allies us to the fish; and in Section XIV, to add a note on the Psychology of Plants.

Several critics have evidently overlooked the distinction which I carefully pointed out between Evolution and Darwinism on pages 20 to 22.

**WILLIAM W. KEEN.**

**January, 1923.**



## PREFACE

I HOPE that this little book may realize my earnest aspiration as expressed in its Dedication and serve to dispel the fears of some earnest Christian people that "Science and the Scriptures" (the original title of the address) are incompatible. I find no difficulty in sincerely believing in both. Every year in a very long life, devoted especially to scientific teaching and writing, has only strengthened my belief in both.

A fundamental difficulty with the so-called "Fundamentalists"—is that they fail to recognize the fact that the "Children of Israel," for whom the Pentateuch was written, were Orientals and were living in the intellectual childhood of the human race. Had God sent this message

to them in the modern matter-of-fact Occidental form, they would hardly have comprehended it, and might easily have rejected it. Their minds were cast in a poetic mold, their literature was permeated with imagery, metaphors and parables. It was delivered to them by bards, priests and prophets. No scientists then existed.

In this age of general education, I can hardly believe that the most sincere literalist can insist that while Adam was made unconscious, an actual rib was taken from his body and out of it was fashioned a woman; and that Eve and a serpent actually conversed together in intelligible speech. To those who are familiar even in a general way with Oriental literature, all this is clearly to be understood figuratively and not literally. So too, the description of the "holy Jerusalem," whose

“light was like \* \* \* unto a jasper stone clear as crystal \* \* \* and the City was pure gold, like unto glass \* \* \* and the twelve gates were twelve pearls, every several gate of one pearl,” etc., cannot possibly be understood as a literal description.

Moreover, as pointed out by Prof. Piper in *Science* for July 28, 1922, if we accept the Chronology of Archbishop Ussher, that the world was created in 4004 B.C., and that Adam and Eve were the only progenitors of the present races of mankind, “white, yellow, red, brown and black \* \* \* the diversity of their supposed progeny illustrates what the biologist means by Evolution. *The Biblical Story with its logical implications stamps every believer in it as an Evolutionist.*” (Italics my own.)

But no scientist, he adds, “will admit for a moment that human Evolution has pro-



ceeded as rapidly as the story in Genesis necessarily supports" *i.e.*, that such enormous progress could possibly have taken place in only 6000 years—or rather much less than 6000 years, for we know historically that these variously colored races of mankind have existed for many centuries. "The Biblical Story makes Darwin's ideas seem exceedingly conservative. Really, Mr. Bryan [Prof. Piper humorously suggests] ought to attack Darwin as a hide-bound reactionary, instead of a radical innovator whose notions regarding the slow rate of modification in species seriously challenge the truth of Evolution as taught in the Bible."

Jesus himself abolished the Old Testament Doctrine "An Eye for an Eye" by his Authoritative Dictum "But I say unto you." The Epistle to the Hebrews declares that the "First Covenant" has

been superseded by the "Second." Both of these are capital instances of a Spiritual Evolution.

Yet, doubtless, the "Fundamentalists" of that day urged that the sacrosanct "Faith of our Fathers" and that the "Faith once delivered to the Saints," should be upheld against men who "had turned the world upside down."

To me and to many another believer in Evolution, the Bible is the Book of Books. It is a precious manual of Religion but not a text-book of science. It lays down rules of conduct. It is an inspirer of Christian faith and hope. It is the great revealer of God to man through Jesus Christ His Son and our Divine Saviour who "brought Life and Immortality to light."

W. W. KEEN.

Philadelphia,  
October, 1922.



## HISTORICAL NOTE

The occasion for this address was a request from the Faculty of Crozer Theological Seminary through Rev. Dr. Milton G. Evans, the President, that I should deliver the "Commencement Address" on June 6, 1922. No topic was suggested to me. I am, therefore, solely responsible for choosing this subject, and for all the views set forth therein.

The request arose from the following facts:

In 1867 the Crozer Theological Seminary was founded by the children of that honored Baptist, the late John P. Crozer. It is located at Chester, Pennsylvania, on land which the map in Ashmead and Johnson's *History of Chester* shows belonged to my ancestor Jöran Kyn (George Keen). He had been sent

from Sweden by the great Chancellor Oxenstierna in 1642, in the retinue of John Printz, the first governor of "New Sweden." In 1644, he obtained a patent for a large area on the mainland and founded what is now the city of Chester, which originally he called Upland, after his native province in Sweden. William Penn, on landing there 40 years later, changed the name to Chester.

The first public office I have ever held is that of a Charter Trustee of this Seminary. Now, after fifty-five years of service, I am the only survivor of the original Board of Trustees.

Soon after the publication of the full address in the *Public Ledger* of June 11th, and in part in *Science* for June 9th, the Messrs. J. B. Lippincott Company requested me to enlarge it so that they could publish it as a small book. The result is the present volume.

# I BELIEVE IN GOD AND IN EVOLUTION<sup>1</sup>

THERE are two views of the creation of man. One is that God created man, completely furnished, physically, mentally, morally and spiritually, like the heathen legend of Minerva springing full-armed from the brain of Jupiter. The other is that his creation was a gradual, instead of an instantaneous process, starting from a far lower form of animal life, slowly increasing in intelligence, and in his physical, moral and spiritual nature, until he reached his present state. This exactly coincides with the teaching of Evolution in the Scriptures "first the blade, then the

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<sup>1</sup> Commencement address at Crozer Theological Seminary, June 6, 1922, republished with much additional matter. Its original title was "Science and the Scriptures."



ear, then the full corn in the ear.”  
(Mark. 4-28.)

This last view may be likened to the creation and development of the telephone by Graham Bell, in our own day. It has been a gradual evolution. Even to-day it has not yet reached its full development. Every day adds new marvels. Nor has man yet reached *his* full development. For myself, I believe that man, himself, will only attain his final development in the future life beyond the grave. In that wondrous life I believe as firmly as I do in my own present existence.

Do I also believe in Evolution? Most assuredly. And for the very best of reasons, *viz:* that I see the evidence of it all around me every day. Even in my own lifetime I have seen a wonderful evolution in vegetables, in fruit, in flowers,<sup>2</sup> in pig-

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<sup>2</sup> Compare the original wild rose of my boyhood, with its ring of only five petals, with an American Beauty rose.

eons and chickens, in the dog, the cow and the horse. If so great progress is possible in the few decades of one human life, what is not possible in thousands and even millions of years, for the earth undoubtedly has existed for many millions of years. The Chronology of Archbishop Ussher—who lived three centuries ago (1581-1656), when Paleontology, Geology, Anthropology, Philology, Chemistry and the Spectroscope were in their infancy, or even did not exist—is a man-made addition to the Bible which has no business to be there. To fix 4004 B.C. as the date of the Creation is not only untrue, but has worked immense harm. Even the *Watchman-Examiner* (December 29, 1921), quotes the fact that copper wire was made as early as 5500 B.C.—1500 years before the world was created according to the Chronology of Ussher. Making such wire proved that

civilized man had already existed for many, many years, or even many centuries.

Dr. Schlesinger, the Professor of Astronomy at Yale, says that "many of the stars \* \* \* are so distant that it takes more than a million years for their light, [traveling at the rate of 186,000 miles a second] to reach us, and it is probable that some of them may require five million years or even more." He adds that there is "good evidence that the age of the earth must be reckoned, not in mere millions, but in billions of years."

The attitude of the Church, and especially of the Clergy, towards science and towards the origin of man is of incalculable importance. Darwin's *Origin of Species* was published in 1859, the year when I graduated at Brown University. The recrudescence of the warfare over Evolution, which for many years had sub-

sided and almost disappeared, except sporadically, is a strange and surely only a passing phenomenon. The illogical and futile attacks upon science by some of the miscalled Fundamentalists, and an illogical and even absurd attempt to prove that the Bible contains and anticipated the discoveries of modern science, are doing immense harm to religion. There is serious danger, if present tendencies triumph, that intelligent people—those who eventually mold the thought of the world—will be alienated from the Church and finally driven out of it. It is not without deplorable significance that Lord Bryce, in his *Modern Democracies*, (II, 326) states that in Argentina and Brazil, “Men of the educated class have practically dropped Christianity.”

The Bible is a text-book of Religion and not a text-book of Science. Like our com-

mon speech of to-day, its language is popular, not technical. Sage and wayfaring man alike find in it guidance and comfort in this mortal life, and the Gospel, the good news of an Immortal Life through our Lord Jesus Christ. The "Impregnable Rock of Holy Scripture" and the impregnable rocks of the geologist are equally God's handiwork, and rightly interpreted must agree.

Mr. Bryan and many others, especially the so-called Fundamentalists, confuse Evolution with Darwinism. They believe them to be identical. On the contrary, Evolution long antedated Darwinism. I cannot state the distinction between them better than in the words of Prof. James H. Robinson (*Science*, July 28, 1922, p. 95) as follows:

"Recently a serious misunderstanding has resulted from the report that men of

science are giving up 'Darwinism,' that 'Darwinism is dead.' This has puzzled those who supposed that Evolution was a well-substantiated assumption, and has filled with a somewhat malicious joy those who have always denounced the notion as wicked and opposed to Scripture.

"But to the biologist, Darwinism does not mean the theory of man's animal descent, which was formulated long before the publication of the *Origin of Species*, but is confined to the ingenious theories which Darwin so patiently worked out to account for the facts of Evolution. The statement that Darwinism is dead does not mean that the evidence for the evolutionary hypothesis has in any way been weakened so that any really competent man of science doubts our animal derivation. It only means Darwin's explanations of how one species may have been

derived from another, has proved, as a result of increasing knowledge, to be mistaken or wholly inadequate."

Or again in the words of Prof. H. E. Walter, of Brown "as the analysis of the living world, gradually came to shift from species to individuals it was shown that individuals may be regarded as simply aggregates of *unit characters* which may combine so variously that it becomes more and more difficult to maintain constant barriers of any kind between the groups of individuals arbitrarily called 'species'."

Bateson himself, who has been misquoted as an opponent of Evolution, says: "Let us proclaim in precise and unmistakable language that our faith in Evolution is unshaken. Every available line of argument converges on this inevitable conclusion."

I propose in this address to approach Evolution not from the controversial side,



or from general arguments, but from a plain statement of a series of specific *facts*, many of them drawn from my personal experience as a surgeon and anatomist—facts which, to my mind, absolutely demonstrate the solidarity of animal life, more especially in the case of the vertebrates, such as fish, birds, other mammals and man, the highest mammal.

Plant life I shall consider later. (See page 89.)

Many opponents of Evolution admit the gradual development of animal life from its lowest form up to and including the anthropoid apes, but they draw the line there, basing this belief on the account in Genesis. Man, they insist, stands as a separate direct creation by the Almighty, "out of the dust of the ground." Such an argument is like declaring that the laws of mathematics reign in numbers up to say,

100,000 or 1,000,000, but beyond that limit are no longer valid.

I have been a student and teacher of Anatomy and Surgery since 1860, a period of sixty-two years. I have diligently striven to know these two subjects as thoroughly as possible, and have written hundreds of papers and some books, in which I have set forth this knowledge.

On the other hand, I am a firm believer in Christianity. I follow, very falteringly, it is true, in the footsteps of my beloved Master, and adore Him as my Divine Saviour. In Him are all my hopes for the future. As a Christian man, I find no difficulty whatever in believing absolutely in Evolution, and also absolutely in Revelation.

Let me now point to facts—not theories, but facts—which demonstrate this unity of the animal kingdom, including man.

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# I BELIEVE IN GOD AND IN EVOLUTION

## I.

### OPERATIONS ON THE BRAIN

I. Let me relate some operations I have done on the human brain. The brain in animals, including man, consists in a general way of—(a) The Cerebrum; (b) The Cerebellum; (c) The Spinal Cord; and (d) certain structures which bind these three together. Extend the fingers straight forward. The fingers then resemble the “convolutions” on the surface of the brain; the furrows between them resemble the “fissures” between the convolutions of the brain. The convolutions, however, are more or less curved, instead

of being straight as are the fingers. Every cook knows the appearance of the brain. The principal fissures between the convolutions are similar in man and animals.

In the convolutions on the surface of the brain are certain small aggregations of microscopic motor nerve cells in the gray matter called "motor centers." On being stimulated by an electric current, these cells produce motion, each center in one definite portion of the body, and never in any other part.

These motor centers are all grouped around the fissure of Rolando, which runs obliquely downward and forward above the ear. (Fig. 1.) This, and another deep furrow called the fissure of Sylvius, are always readily identified in the lower animals. The motor centers for movements of the leg, arm, face, fingers, etc., in the brains of the lower animals, up to

the anthropoid apes, have been exactly mapped out by experiments on animals. In the human brain the location of the cor-

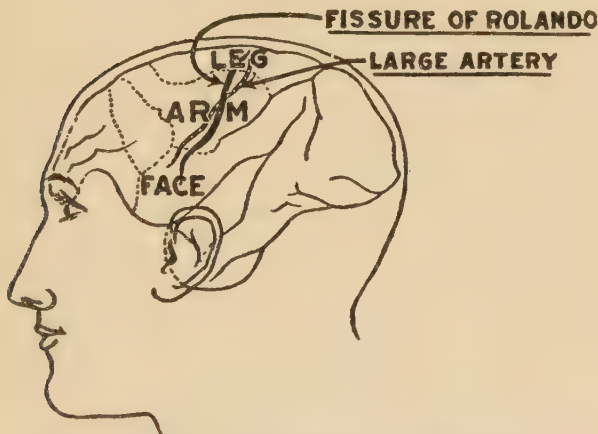


FIG. 1.—Shows the location of the Fissure of Rolando, the location of the areas in which the “motor centers” for the leg, arm (including those for the hand) and the face are situated. Also the position of the large artery which was torn in the case of the Annapolis Midshipman.

responding motor centers is a duplicate of those in the brains of animals. Let me relate some striking cases to confirm this statement.

A young woman with epilepsy, whose attacks were constantly increasing in fre-



quency and violence, insisted that her attacks always began in her left thumb, then spread to the hand, then to the arm, followed by unconsciousness and violent convulsions all over the body. Careful observation for two weeks in hospital confirmed her statements that the fits always did begin in her left thumb. If, then, I could prevent the fit from beginning in this thumb, so I reasoned, it might be that I could prevent the entire attack. Just as, in a row of bricks standing on end, if I can prevent the first one from falling, none of the others will fall.

The possibility of the exact localization of the little cube of gray matter on the surface of the brain, dominating all the muscles of the thumb, was the key to the whole operation. This localization of the thumb center had been fixed absolutely by experi-

ments on the brains of animals. Accordingly, I opened her skull, identified the spot corresponding to the thumb center in animals, (*i.e.*, the great toe of the front foot) and cut out a small cube less than an inch on each side.

Next, note the fact that there are nine muscles moving the thumb, some in the ball of the thumb, some between the thumb and the forefinger, some extending up the front of the forearm, and some up the back of the forearm, both of the latter reaching nearly to the elbow. Some flex and some extend the thumb, some separate it from the other fingers, and by one we can make the thumb touch each of the other four fingers. This is the motion which differentiates the human "hand" from the animal fore "foot."

When this patient awoke from the ether, *every one* of these nine muscles was para-

lyzed and in *not a single additional muscle* was motion abolished! The human brain center and the animal brain center for the thumb were proved to be *precisely identical*. My hopes were justified. Her epileptic attacks, which had occurred almost daily, recurred only about once in a year. In a few months she even regained full control over this thumb.

Two other later similar cases still further confirmed this wonderfully exact localization.

A fourth brain case: In 1888 I reported my first three cases of modern surgery of the brain. Attending the meeting of the American Surgical Association in Washington, when I read this paper, was Sir David Ferrier, of London. He had contributed very largely to this then wholly new mapping of the brain centers controlling motion. In one case I de-

scribed how, by the battery,<sup>1</sup> I had stimulated a certain small, definite motor area in the brain of my patient, the location of which had been also determined by experiments on the brain of animals, and described the resulting movements of the arm at the shoulder. Ferrier afterwards said to me, "I could hardly restrain myself from leaping to my feet, for this was the very first demonstration on the human brain of the exact identity of my own localization of this very center in animals."

A fifth brain case: A midshipman in the United States Naval Academy at Annapolis, in 1902. I saw him three days after his accident. All the history I obtained was that he had been injured in a football game, had been unconscious for half an hour, and since then had complained bitterly of headache, which he

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<sup>1</sup> The brain itself is wholly devoid of sensation and can feel no pain.

located in his forehead. He was almost comatose, his pulse was only 52. There was no fracture of the skull. Soon after the accident, he developed local convulsions—note this carefully—first in the right leg and later and chiefly in the right arm, but never involving the face. In six and a half hours he had had twenty-four of these convulsions, all in the right arm. The only local evidence of any injury was a slight bruise at the outer end of the left eyebrow. Had I seen this case prior to 1885—when I first made a careful study of the motor centers in the brain—I should have followed, of course, the only visible indication of the location of the injury to the brain, namely, the bruise. Had I opened his skull near the bruise, I should have been confronted with a perfectly normal brain. I should then have been compelled to close the wound and perforce

have done nothing more. He would have died within two or three days.

But experiments on animals, had shown that above the ear and a little in front of it, lay the centers controlling the muscles of the face, the arm, and the leg, from below upwards, the leg center being near the top of the head. Fig. 1.

As there was no fracture of the skull, and as the convulsions began first in the leg and then concentrated chiefly in the arm, but never extended to the face, my diagnosis was a rupture of the large artery on the surface of the brain over these motor centers; that the escaping blood had formed a clot, the edge of which first overlapped the leg center, but that the chief mass of the clot lay over the arm center. Moreover, I felt sure that it had not yet reached downwards over the motor center controlling the muscles of the face.

Evidently, this clot must be immediately removed or he would quickly die. I opened his skull directly over the center for the arm muscles, and far away from the bruise. The opening in the skull at once disclosed the clot, the thickest part of which did lie exactly over the arm center, as I had foretold. I removed three-quarters of a tumblerful of blood, which had caused the headache, the somnolence, the slow pulse and the convulsions; then tied the artery, and closed the wound. He made an uninterrupted recovery. He entered the Navy, but some years later lost his noble life in saving his ship and the crew from destruction by a fire near the powder magazine.

Do not such exact localizations of the brain centers in animals, as directly applied to man, in hundreds, if not thousands of operations by now, most closely ally man to animals?

## II.

### HUMAN AND ANIMAL SKELETONS

II. Go with me next into the Museum of the Academy of Natural Sciences in Philadelphia, and compare the skeleton of man with those of the lower animals. Practically, these animal skeletons all closely resemble the human skeleton, though when clothed with flesh and skin they look very unlike.

All of the ape and the monkey skeletons are practically replicas of the human skeleton.

Look at the many skeletons with five toes—the prevalent or typical number—such as those of the cat, tiger, bear, elephant, etc.<sup>1</sup> Observe, for instance the

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<sup>1</sup> Sometimes in the hind leg there are only four toes, or the fifth, if it exists, is rudimentary.



front and hind legs that correspond to the arm and leg in man. Bone for bone, they are counterparts of the human skeleton—shoulderblade, humerus, radius and ulna (the two bones of the forearm), and those of the hand; with a similar correspondence in the bones of the hind leg and human leg.

Nothing could be more unlike exter-

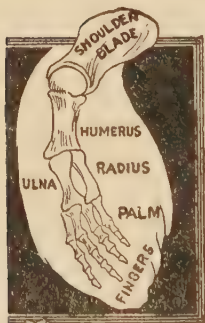


FIG. 2.—The bones of the arm are masked within the skin of the whale flipper.

nally than the flipper of a whale and the arm and hand of a man. Yet you find in the flipper the shoulderblade, humerus, radius, ulna, and a hand with the bones of four fingers masked in a mitten of skin. (Fig. 2.)

Note also that not only the bones but the muscles, nerves and blood-vessels in the arm and the flipper also correspond.

## HUMAN AND ANIMAL SKELETONS 39

Observe the bones of the next chicken you eat. You will find in the wing the counterpart of the shoulderblade, the humerus, and the radius and ulna. The terminal bones of the bird's wing, *i.e.*, the hand, are only three in number, the bones corresponding to the little finger and the ring finger being absent. They are thus modified to support the feathers. It is a hand altered to suit the medium in which birds move so gracefully.

While undoubted evidence shows that man has existed for only about 500,000 years, the horse has a consecutive geological history of over 3,000,000 years. The skeleton of the earliest horse, which was scarcely larger than a cat, had four toes in front and three behind. Gradually, all the toe bones except one—the middle toe—have been lost. But the second and fourth digits, though they do not show

externally, are represented by two rudimentary bones, the two "splint bones."

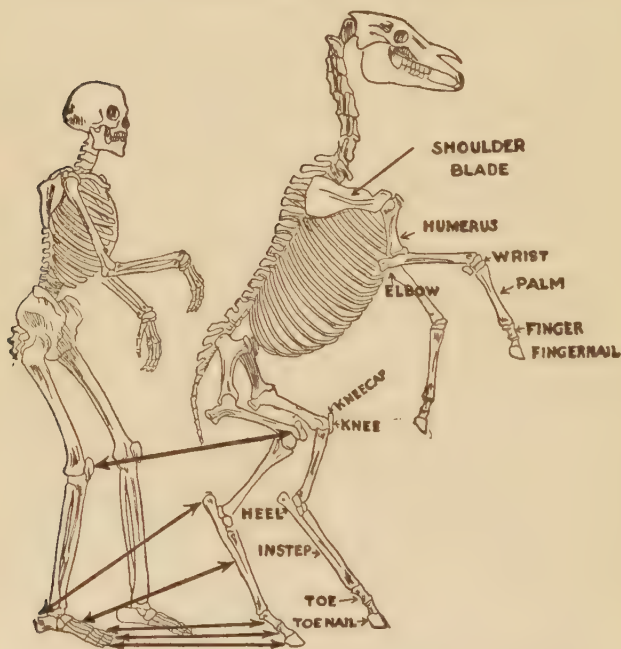


FIG. 3.—The skeleton of a horse and a human skeleton compared.

The horse of to-day walks literally on tip toe, for the hoof is the toe- or finger-nail. (Fig. 3.)

### III.

## THE HEART

III. The internal organs of the body have the same story to tell of likeness or identity. Let us first look at the *heart*. You all know there is a right side of the heart which sends the blood through the lungs to be oxygenated, and a left side, which sends the blood to all the rest of the body. Each of these sides has two cavities—the auricle to collect the blood, the other, the ventricle, with strong muscular walls, to drive the blood on its long journey. These four cavities are all united into one heart, with an important *groove* on the surface, marking a partition between the two auricles above and the two ventricles below.<sup>1</sup>

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<sup>1</sup>Get a bullock's heart at market and note these facts.

A steady, rythmical action of the four cavities is essential for the proper propulsion of the blood, and, therefore, for health and life. The four cavities act, not all at once, but in succession, like the feet of a walking horse—1, 2, 3, 4; 1, 2, 3, 4, each foot having its own number. Until 1892 we did not know exactly what regulated this orderly sequence. In that year, the younger Doctor His discovered that in the groove between the auricles and the ventricles there is a small bundle of muscular fibers which exists as one bundle until it reaches a certain point. There it divides into two smaller bundles, one going to the muscles of the right side of the heart, and the other to those of the left side.

But the great importance of this “bundle of His” was not fully appreciated until twelve years later (1904). If, under an anesthetic, an animal’s chest is opened, the

heart laid bare, and this "bundle of His" is injured, the rhythm of the successive contracting of the walls of the four cavities of the heart is at once disturbed. Instead of 1, 2, 3, 4, the order might be 1, 4, 2, 3, or 1, 3, 2, 4, etc. This fluttering of the heart threatens life. If the bundle is destroyed, death quickly follows.

In man, such physiological experiments, of course, are forbidden, but occasionally disease maims or destroys this bundle of His in the human heart itself. A small tumor named a gumma, in a few cases, has formed directly in or near the bundle of His, and in some cases has destroyed it. This has deranged the action of the heart of the human patient, just as the physiologist did in the experimental animal. Severe flutterings of the human heart, with difficulty of breathing, a pulse slowed down from 72 to 20, 10, or even 5 in the

minute were observed. Not seldom sudden death occurred. The post-mortem in these cases disclosed the tumor, or other cause, which had injured or destroyed this bundle of His, and was the immediate cause of death.

Now, this bundle of His is found in all vertebrates, in man and other mammals, in birds, and even in frogs and fishes. This certainly shows the solidarity of the entire animal kingdom. Such exact parallels between the human and the animal body strongly suggest, one may even say prove, a close interrelation of the two.

## IV.

### LIVER AND DUCTLESS GLANDS

IV. The Liver and the Ductless or "Endocrine" Glands. Everybody knows that the liver secretes bile, or gall. The bile, which is necessary for proper digestion, is discharged into the intestines through a tube called the bile duct. The gall bladder is simply a reservoir for extra bile, and a sturdy means of support for us surgeons, especially in the late hard times, by reason of the dangerous gall stones which form in it and require removal by a surgical operation.

Now, in 1848, Claude Bernard of Paris, one of my own teachers in the middle 60's, discovered that the liver had a second function totally unsuspected until then. Practically all the blood from the intestines goes through the liver on its way back to the



heart. Bernard opened the abdomen of a fasting animal, drew some of the blood *before* it entered the liver, and also some of the blood *after* it had gone through the liver. He found that the blood, before it entered the liver, was sugar free, but after it emerged from the liver, it always contained *sugar*. This was the first step in the scientific study of diabetes, in which there is an excess of sugar which is excreted through the kidneys.

But the liver has no second duct or tube for the discharge of this sugar into the blood current. Being in solution, the sugar soaks through the thin walls of the blood vessels into the blood current as it passes through the liver.

Following this came later the discovery of the now numerous "ductless glands" of which we have learned so much chiefly by animal experimentation in the last few years. Some of them, though only as large as a pea, are essential to life itself.

## V.

### THYROID GLAND

V. Let me now say a few words about one of the most important of these “ductless glands”—the Thyroid Gland in the neck. When it becomes enlarged it is familiar to us as a “goiter.”

From this gland, as in the case of the liver, there soaks into the blood stream circulating through the thyroid, a secretion of great importance to life. If the gland is rudimentary, either in substance or in function, it results in that form of idiocy known as cretinism. As a remedy we have learned to administer an extract from the thyroid glands of animals. The remedy is usually remarkably successful. In certain conditions, goiter is very prevalent in the thyroid gland of brook trout. It has

even threatened to destroy the culture of these food fishes (Kendall, *American Journal of the Medical Sciences*, May, 1922, p. 634). By the administration of iodine, this disease has been prevented in the trout. As a result of this success the same method has been tried and found efficient in preventing goiter in human beings.

Here, again, you perceive the solidarity of the animal kingdom in such identity of function that the thyroid gland of animals, when given as a remedy to man, performs precisely the same function as the human thyroid. Moreover, it is not the thyroid gland from the anthropoid apes that is used as a remedy, but that from the more lowly sheep.

## VI.

### SYMPATHETIC SYSTEM

VI. The Sympathetic Nerve and its wonderful phenomena. When I was a student of medicine one of our text-books was *Dalton's Physiology*. In connection with the sympathetic nerve, there was a picture of a cat, of which the "Chessy cat" of *Alice in Wonderland* always reminds me, for in both only the face was pictured.

The sympathetic nerve in the neck is a slender cord about as thick as a fairly stout needle. It runs vertically on each side of the neck, alongside of the carotid artery and the jugular vein, and so close to them that a dagger-, a knife- or a bayonet-thrust, or a bullet, which would cut the nerve, would almost surely cut the

great artery and the vein. The patient then would bleed to death in a few minutes and never reach a hospital. Hence, no one had ever had a chance to observe the effects following division of this nerve in man. Before Brown-Séquard's experiment on animals, in 1852, its function, therefore, was entirely unknown. By a small incision he exposed the nerve in the neck of a cat, rabbit and other animals, divided the nerve, and observed what happened. The small wound healed quickly.

These results were as follows: 1. The pupil of the eye on the same side as the cut nerve diminished from the normal large sized pupil in the cat to almost the size of a pin hole. 2. The corresponding ear became redder from a greatly increased flow of blood, *i.e.*, the blood vessels were greatly dilated. 3. On that side there was increased sweating, that is, the

sweat glands became very active as a result of the greater blood supply. 4. The temperature increased to a marked degree; in rabbits, by seven to over eleven degrees Fahrenheit.

Dalton's picture of the cat's face could never be forgotten, because the two pupils differed so greatly in size.

In 1863, during the Civil War, when I was Assistant Executive Officer of a military hospital, one day a new patient approached my desk just as I was about to sign a letter. The moment I looked up at him I was struck with his appearance and instantly said to myself, "Surely you are Dalton's cat." "Where were you wounded?" I quickly asked. He pointed to his neck, and I said to myself, "His sympathetic nerve must have been cut." Further careful observation showed the reddened ear, the increased temperature, the sweat-

ing and the greater flow of saliva, thus confirming in every particular the results of Brown-Séquard's experiments on animals. It is interesting to know that this was the very first case in surgical history in which the effects of cutting the sympathetic nerve had ever been observed in man.

Further experiments on this little nerve in animals revealed a wholly new world of most important phenomena. It was discovered that the sympathetic nerve sent branches to every artery in the body, from head to foot. Now the arteries are tubes, like the water pipes in a house, not, of course, rigid like metal, but soft and flexible, for they consist largely of muscular fibers which contract or relax automatically, making the arterial tubes of a larger or a smaller diameter according to the need for more or less blood.

For instance, just before a meal, the

stomach is of a dirty yellowish-brown color. Not a single blood vessel is to be seen. An hour after the meal the stomach has become so red that it looks almost as if the wall of the stomach was made up of nothing but blood vessels. This greatly increased supply of blood is needed to secrete gastric juice for the digestion of our food, and for the active churning movements of the stomach during the process of digestion. As the food is digested, less and less blood is needed, and, under the influence of the sympathetic nerve, the caliber of the arteries is gradually diminished by the contraction of their muscular walls, until the stomach looks as bloodless as before the meal.

How fortunate that all this is automatic! Were it not, and after breakfast you forgot to order an increasing supply of blood for digestion, or if after digestion



was accomplished, you forgot to shut off the blood, what would become of you?

The iris, the colored circular curtain inside the eye, with a round, black hole in the center called the pupil, is under similar automatic control of this sympathetic nerve. The iris is like a wheel. Around the pupil there are circular fibers which one may call the hub, while the rest of the iris consists of radiating fibers corresponding to the spokes. When you go out of doors, the bright light at first almost blinds you, but very quickly the circular fibers around the pupil contract so that the pupil becomes as small as a pin hole and protects the retina. On going into a dark room, the pupil is automatically dilated. This, combined with a wonderful physiological adaptation in the retina, enables us in time to see clearly everything in the room.

The chief center of the sympathetic

system of nerves is at the familiar "solar plexus," which lies in front of the spine at the level of the "pit of the stomach."

When you blush from emotion, the arteries of your skin have dilated. When you turn pale with fright, the caliber of your arteries is lessened, and if the arteries going to your brain supply too little blood, you fall in a faint. When you cut your hand, you know how all around the cut the redness shows that the arteries have dilated to furnish extra blood for the repair of the injury, and when the wound is healed, your blood vessels again gradually contract, and the redness disappears.

All these processes also are automatic. You do not have to remember to order blood to or from a cut hand, or to contract or widen the pupil, etc. It is all done for you; in fact it is done in spite of you, for you have no control over these varying con-

ditions.<sup>1</sup> The automatic action of this nerve is of the utmost importance for many functions involving life itself.

I could go on almost indefinitely with a multitude of similar illustrations. All of our knowledge of these facts started from Brown-Séquard's little experiment of cutting the slender sympathetic nerve in the neck of an animal.

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<sup>1</sup> This is not strictly true. In certain circumstances, by many repeated efforts, one can slowly gain some control over these emotional effects, but not over the necessary physiological reactions such as the pupil, etc.

## VII.

### ANCESTRAL VESTIGES

VII.. Another evidence of our animal origin is found in organs which are well developed and actively functioning in some of the lower animals, but which in man have retrograded. The horse can get rid of flies by active wriggling movement of his skin, a faculty almost lost in man. He can also turn his ears to and fro; not a few human beings having preserved this function but to a much less degree than the horse. The best known example of a Vestigial organ is the appendix, which, in some of the lower animals, is well developed and functions actively. Its frequent inflammation is also a good example of the fact that such imperfect vestigial organs are very prone to become diseased and

often require the surgeon's skill to avert disaster. The only really safe place for the appendix is in the surgeon's collection of trophies.

As Prof. Walter (*loc. cit.*) happily says of the appendix and the many other similar vestiges from our animal ancestors: "These and scores of similar characters, which, taken together, make man in the eyes of the comparative anatomist a veritable old curiosity-shop of ancestral relics, are the last traces of characters which formerly had a significance in some of man's forbears. Having lost their usefulness, these structures still hang on to the anatomical household as pensioners. They have not been recalled from the past, but have always been with us, although of diminishing importance."

## VIII.

### IDENTICAL DISEASES

VIII. The Evidence from the Diseases of Man and Animals. So complete is the fundamental identity of a number of these diseases that we can solve problems in human disease by a study of the same disease in animals.

Inflammation is common to most diseases. The major part of our knowledge of this process has been derived from study of inflammation in the web of the frog's foot. There we can catch the initial steps of the process, information which it is absolutely impossible to obtain in man's body. At human post-mortem examinations, we can obtain by microscopical and chemical examination only the end results,

not the beginnings of disease. Moreover, frequently complications have occurred during the course of the disease which have obscured or even destroyed the evidences of the original disease. In animals, we can painlessly end their lives by an anesthetic at any desired period of the disease and learn step by step what has occurred.

Among the diseases common to man and animals, I may mention inflammation of almost all the tissues and organs of the body, such as inflammation of bones and joints, etc., abscesses, anthrax, glanders, hydrophobia, tumors, tuberculosis, cancer, and tetanus. I can only say a few words about the last three.

After Koch discovered the bacillus of tuberculosis in 1882, we learned in a few years both by clinical experience in man,

and by many experiments on animals, more about this disease than in all the years since its first recognition. In my boyhood and even young manhood, every patient was regarded as doomed the moment that the diagnosis of "consumption" was made. Hope was practically abandoned. Now, if diagnosed *early*, it is very curable. Moreover we took no precautions to prevent the disease from spreading, we did not know that it was contagious. No means were taken to prevent coughing and spitting. We did not know how to make an early diagnosis by finding the tubercle bacilli in the sputum. These precautions and an early diagnosis when the disease is in its most curable stage, have come very largely from our studies of the disease in animals.

Cancer is the most baffling disease that



we have to deal with for the reason that its cause is unknown and we are fighting it to a large extent in the dark. It exists among animals as well as man. I have seen and handled at the Cancer Institute on the Embankment in London, many mice with cancers as large as their own bodies, or even larger. I could not see that they were "suffering" from cancer, for they were running about in the liveliest fashion and seeming to be having "the time of their lives."

Cancer is being attacked from the clinical, the microscopical, the chemical, the experimental, the biological and the surgical side. That we shall discover the cause is absolutely certain. Any day the good news may come. Experiments on animals have given us a deal of knowledge about it. We are gradually closing in on

this enemy of man and animals, and will assuredly slay it.<sup>1</sup>

Tetanus or lock-jaw is another disease common both to animals and man. The germ is found in soil roamed over by animals, for the usual home of the tetanus bacillus is in the intestines of horses and

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<sup>1</sup> May I digress for a moment to say that the only hope of cure at present lies in an early and complete extirpation of all the disease. Let me impress upon every reader of these lines a few facts. The absence of pain is no indication that the disease is harmless. *Cancer is almost never painful in the beginning.* The first evidence of the disease is usually a lump which ought not to be there. The moment that such a lump is discovered, instantly the best up-to-date surgeon available should be consulted, and if his judgement approves, an immediate wide and thorough removal should be done.

Cancer has become a national menace. It is increasing faster than the population is increasing. If these words will carry weight and result in prompt action by any of my readers this digression will be amply justified, for *a very large percentage of cancers can be permanently cured by an early and complete surgical operation.* I know of no other means of cure at present. When we learn the cause, then I expect the happy day will dawn when we will be able to prevent or to cure cancer without operation.

cattle. The bacilli and the animals live very happily and comfortably together, so long as the bacilli remain in the intestine, but, as was often shown in the late war, if a horse received a wound and tetanus bacilli from the soil got into the tissues and infected the wound, the horse died of tetanus, precisely as a man would.

By experiments on animals we have now discovered an antitoxin which will prevent this horribly painful disease, provided it is used early enough. The prevention of tetanus was one of the great triumphs of the Great War.

## IX.

### CELLULAR ORIGIN OF LIFE

IX. Man, animals and plants all originate from a one-celled ovum (egg or seed). One of the most remarkable things in the world is a human ovum. From a single cell when fertilized, there develop myriads and myriads of cells. These cells quickly begin to differentiate into the various tissues and organs of the body: bone, muscle, nerve; heart, liver, kidney; or into those still more wonderfully complex organs, the eye, the ear, and the brain. Moreover, the later exact color of the eyes, of the skin—white, black, brown, etc.,—along with other racial qualities of body and mind, straight or curly hair, Grecian, Roman, Jewish, Negro nose; the oblique, Asiatic eyes, the longer

arms and projecting heel of the negro, the high cheek-bone of the American Indian. There are always symmetrical pairs of eyes, ears, nostrils, arms, legs, brain (in right and left hemispheres) lungs, kidneys, ribs, etc., but only one liver, stomach, pancreas, spleen, etc. "Why, in the embryo, should the little bud which is to become a human arm always develop at exactly the right place and not grow out on the front of the chest or on the back nearer the spine? \* \* \* Why should the two arms (and the two legs) always grow to virtually the same length? Why should the human body grow for about twenty years and then stop growing?" The only answer is that in that tiny primordial cell were enshrined all the orderly sequences and potencies of human development.

Still more subtle is the reproduction in varying degrees of the mental and moral,

as well as the physical traits of both the parents.

What enormous potentialities are enwrapped in that tiny single cell!

What an enlightening fact it is that this origin from a single cell extends from man down to the very worm. You recall how Pasteur saved the silk industry of France from ruin by discovering in the eggs of the silk-worm the cause of the deadly pébrine, and that he could easily distinguish between the diseased and the healthy eggs. Even as low a form of life as the sponges have a similar origin.

All many-celled animals and plants arise each from one fertilized ovum. In plants we call them seeds, and in Holy Writ the promise was to Abraham and his "seed," making "seed" and "egg" synonymous philologically as they are physiologically.

This is the message of all Nature—like

the rocks, another of God's works—progressive development from the lowest to to the highest form of life, from a single cell to the complete man, from the unknowing baby to the wonderful mind of the sage.

Let me conclude this section by a quotation from the reply of Professor Conklin, one of our most eminent scientists, to Mr. Bryan, one of our most eminent orators.

“It is a curious fact that many persons, who are seriously disturbed by scientific teachings as to evolution or gradual development of the human race, accept with equanimity the universal observation as to the development of the human individual—mind as well as body—from an egg. The animal ancestry of the race should be no more disturbing to philosophical and religious beliefs than the germinal origin of the individual, and yet the latter is a

fact of universal observation which cannot be relegated to the domain of theory and which cannot be successfully denied. If we admit the fact of the development of the entire individual from an egg, surely it matters little to our religious beliefs to admit the development or evolution of the race from some animal ancestor, for who will maintain that a germ cell is more complex, more perfect, or more intelligent than an ape? If the evolution of a species is an atheistic theory, as some persons assert, so is the development of an individual, for natural development involves identically the same principles as does evolution. If one concedes the fact of individual development without supernatural interference, one might as well concede the fact of organic evolution without supernatural creation, so far at least as its effects on theology are concerned."





## X.

### EMBRYONIC DEFORMITIES

X. Let us turn to the very significant evidence of our animal origin in the embryonic development of man. I have time to note only two very enlightening instances.

During the pre-natal development in man, between the right and left upper jaw bones is a triangular bone, which carries the four upper incisor or "front teeth." In sheep and some other animals, this bone always persists as a separate bone, called the premaxillary bone. At birth, and afterwards, in the human skull, there is normally no such bone, because it has become fused on each side with the corresponding upper jaw bone. Now note a curious defective development in human

fetal life. Sometimes this premaxillary bone in the human embryo fails to unite with the upper jaw bone on the right or the left side, and then we have what you all know as a "cleft palate." If not only the bones fail to fuse together, but this failure extends also to the upper lip, we have a "hare lip," so called because of the normal notch in the hare's upper lip. We see in some cases only a cleft palate, in others only a hare lip, in still others, both hare lip and cleft palate. This combined hare lip and cleft palate sometimes exists on both sides. This last is a pitiable deformity, which, however, surgery can sometimes remedy. Ordinary hare lip or cleft palate are very amenable to surgical repair.

When there is such a deformity, it *never* occurs in the middle line or any indifferent place here or there, but invariably on

the right or the left side and *corresponding exactly to the site of the failure of this premaxillary bone to unite with the upper jaw.*

Is not such an exact correspondence between the anatomy and development of the sheep and of the child most significant of the ancestry of the human body?

The second example is the relation between the gills of fishes and of other water-breathing vertebrates and the abnormal openings sometimes found on the side of the neck in human beings. These openings, which constitute abnormal communications between the exterior and either the lower part of the throat or the gullet, are the vestigial remnants of openings which in fishes are permanent and constitute the gills or breathing-apparatus.

The embryonic conditions of these openings or clefts are practically identi-

cal in fishes and in the higher vertebrates, including man. As development proceeds, however, marked divergence occurs between the two types. In the fishes, the margins of the openings become richly supplied with blood-vessels, and subserve the same function for the fishes as the blood-vessels of the lungs for the air-breathing animals. In the later, including man, the openings are gradually closed by the overgrowth and coalescence of their margins, leaving no trace in the normal adult of the air-breathing class. As noted above, in exceptional cases complete closure fails to occur, resulting then in congenital openings in the neck—which are very annoying, owing to a constant discharge.

## XI.

### EVIDENCE FROM THE STUDY OF HEREDITY

XI. The evidence from the study of heredity. The wonderful and exact experiments on plants by an Austrian monk—Mendel—only discovered in an obscure local scientific journal, 50 years after their publication, gave a new impetus to the study of heredity. These phenomena have been studied in horses, dogs, cattle, sheep, fowls, mice, rabbits, etc., and in various insects, as well as in plants.

Scores of scientists, European and American, have rewritten and are still developing the science of genetics and applying the results of their investigations to man himself. The same laws relating to

heredity hold good from human parent to child and later generations in man, in animal and plant.<sup>1</sup>

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<sup>1</sup>For the general reader, Prof. Walter's *Genetics* (Macmillan) is an excellent text-book.

## XII.

### INFLUENCE OF EMOTIONS

XII. Even the normal physiological intense emotions of man and animals are practically identical.

One of the most interesting of Darwin's many books is that on the "Expression of the Emotions in Man and Animals." Their wonderful similarity is most striking. In *Harper's Magazine* for July, 1922, Dr. Walter B. Cannon, the distinguished professor of physiology in the Harvard Medical School, has a most interesting and instructive article on "What Strong Emotions Do to Us." This paper embodies some of the latest discoveries in the identity of the effect of strong emotions in animals and man.

Cannon fully confirms the observations



of Darwin, and indeed who cannot who has seen a dog and dog or dog and cat fight in their initial stages:—the aggressive attitude, the erection of the hair, the snarling and uncovering of the canine (eye) teeth. In man, the same attitude, the clenched fists, the deep breathing, the tense flapping of the sides of the nostrils, the uncovering of the eye teeth, all show the similar effects of intense emotion. Moreover all these modes of physical expression of mental states do not have to be learned, they are inborn, *i.e.*, are a part of our animal inheritance. The illustrations in Darwin's book admirably depict these effects of emotion.

By the X-ray, we can actually follow the process of digestion in a cat or other small animal, can see the stomach churning the food around, and then can follow its progress in the bowel, which by its waves of

muscular contraction propels the food along the alimentary canal. If, during digestion, a cat in a cage is greatly excited (by a dog fiercely barking at it, but unable to reach it), all these processes stop. "The churning stomach becomes a flabby inactive sac, the kneading intestines cease their motions, and the digestive glands no longer secrete the juices necessary to prepare the food for absorption." These same effects of intense emotion on digestion have been proved to be true also in man.

An accompaniment of this cessation of digestion is that far less blood is sent to the entire alimentary canal, twenty-five feet in length. This blood is diverted from the alimentary canal to the brain, the heart, the lungs and the muscles. These organs are now all prepared for fight or flight by reason of this greater blood supply. The brain is more active, the heart beats faster,

respiration is deeper and faster to supply the blood with more oxygen. If the flight or fight ensues, there is a burning up of tissue and the production of waste products, especially water and carbon dioxid (carbonic acid). The amount of the carbon dioxid may be even six times greater than the normal.

All this wide-spread activity demands a supply of energy. This is found in the sugar in the blood produced by the liver. This sugar may be so greatly increased as to appear in the urine. "Half the members of a foot-ball squad at the time of the supreme contest \* \* \* were found to have such an abundance of sugar as a result of their emotional tension." (Cannon.)

But this story is not yet complete. Above the kidney are two small adrenal glands. Their secretion is called adrenin or adrenalin. These two glands are

stimulated to great activity by strong emotion and pour their secretion into the blood in a larger quantity than normal. This secretion coöperates with the nerves to put a stop to all the processes of digestion, and so drives the blood from the long alimentary canal, and sends it to the heart, brain, lungs and muscles. Moreover, a small dose of adrenin quickly restores activity to tired muscles. Everything therefore conspires to enable the man or the animal to flee or to fight.

The adrenin also lessens the loss of blood in case of wounds inflicted in a possible fight, for it causes the blood to clot far more quickly than is normal. This clotting more quickly occludes the wound of any blood vessel which may be torn in a fight. Intense emotion if it finds no expression in strenuous muscular activity, still summons its forces for combat. "Careful observation

of students subjected to severe examinations," says Cannon, "has proved that they not infrequently have so large an amount of sugar set free in the blood that it escapes through the kidneys; the heart beats rapidly; the blood pressure is elevated; \* \* \* probably all of the organic adjustments preparatory to a fight or a flight are fully elaborated."

Read the whole of Cannon's paper of which I have given the merest outline, and also read Darwin's book. The result will be that you will surely conclude that man, himself, dog and cat, lion and leopard, are all different forms of living beings, who mobilize their physical and mental forces after the same fashion and that they must have had a common, far-away ancestor.

So identical are many of the most important physiological and pathological (*i.e.* the normal and the diseased) pro-

cesses in man and animals that the physiologist and the pathologist constantly study them in animals and find that their conclusions drawn from these experiments on animals are entirely true in their applications to man. Without such experiments we should be ignorant of these processes in health and disease and go stumbling along in our effort to prevent and to cure disease. These experiments are always done under an anesthetic excepting a very small percentage (less than 1%). In such cases a special permit by the Director of the Laboratory—a responsible member of the Faculty—is given if the Director approves of the subject and the method of the research. Personally, in over sixty years I have never seen or known of a single instance, nor has Prof. Cannon of Harvard, nor Prof. Starling in England during many years in laboratories of experimental research.



### XIII.

#### EVIDENCE FROM FOSSIL MAN

XIII. There have been discovered several grades of actual prehistoric men. Their skeletons or skulls, their flint instruments, and the remains of their fires are evidences of the grade of their several civilizations. This chain of human ancestors was unknown to Darwin, for nearly all of them have been discovered since his death.

I have myself seen in the natural caverns of southern France the extraordinary and convincing evidences of the assured existence of our immediate ancestors, the Cro-Magnon man, who lived about 25,000 years ago. There are other caves still more remarkable in northern Spain. There are to be seen the work of the first painters



and the earliest sculptors, prehistoric Sargents and Rodins of remarkable skill.

Far from the entrance of the caves, the utter darkness shows that a means for producing artificial light had been devised. On the walls and sometimes the roof in red, white and black colors, are depicted and instantly recognized the outlines of the horse, the bison, the mammoth and other animals. In one place there is a spirited combat between two reindeer stags about to lock horns. There are also a very few figures in relief and in one instance a detached statuette.

Before the Cro-Magnon man came the Neanderthal man, "whom we know all about, his frame, his head-form, his industries, his ceremonial burial of the dead," as Dr. Henry Fairfield Osborn has pointed out. Before him was the Piltdown man; before him the Heidelberg man; still earlier, in Java, the Trinil man. Even in Rhodesia (Africa) the remains of one

early man have been discovered. Still further back in geologic time was the Foxhall man—all named from the localities in which their remains were found. This earliest Foxhall man lived in England before the Great Ice Age, about 500,000 years ago.

The differences between the highest anthropoid apes and the lowest man gradually grow less and less the further we trace them backwards. We must clearly understand that no existing species of anthropoid apes could have been our ancestors. The latter and we are collateral descendants from ape-like species living far, far back in geologic time; before, and probably long before the Great Ice Age. The earth is very big, the various excavations during only half a century have covered only a very minute part of its surface. Every discovery has but confirmed the wonderful story of the ascent of man.



## XIV.

### THE MESSAGE OF PLANTS

XIV. Since I delivered this address, the Gold Medal of the British Medical Association, "for distinguished service" was presented to Sir Clifford Allbutt, Regius Professor of Medicine in Cambridge University, England, on July 25, 1922. One of the reasons given for its being conferred upon him was that he had "pleaded for a broader outlook and demanded that our inquiries into the nature and causes of disease should not be limited to man, nor even to the animal kingdom, but should be extended to plants which present, in a simpler form, problems not dissimilar."

Dr. Erwin F. Smith, of the Department of Plant Pathology in Washington, between 1905 and 1914, issued three volumes

on Diseases of Plants caused by Bacteria. He also investigated with especial care a disease in plants very analogous to cancer in human beings and animals, thus showing again the solidarity of life even in the lower realm of plants.

Again, Sir Jagadis Chandra Bose, Founder and Director of the Bose Research Institute in Calcutta, is a gifted Hindu who has devoted his life to scientific researches on plant-life. These researches have won for him the coveted distinction of Fellowship in the Royal Society of Great Britain.

Some years ago I saw him demonstrate the extraordinary effect of drugs on plants, such as poisoning them by drugs which are poisonous to man and animals. Plants were put to sleep with ether and chloroform. If enough is given, they are killed just as a man is killed. If only a

moderate dose is given, the plant passes into a state of greatly lessened activity, which may be well called sleep. When the anesthetic is withdrawn, the plant gradually wakens and returns to its normal activity, just as a man does.

He demonstrated also that there were impulses very analogous to the nervous currents in the human body. All the activities of plants gradually decline to their minimum toward the end of the night and resume their activity with the oncoming daylight. Heat accelerates these reactions and cold retards them, as in man.

His most recent work is about to be published in a book entitled *Physiology of the Ascent of Sap*. (Longmans, London) A notice of this forthcoming book<sup>1</sup> gives a résumé of some more recent discoveries which have been made possible by two

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<sup>1</sup> Littell's *Living Age*, August 26, 1922, p. 524.

instruments devised by him. The first is called the "magnetic crescograph," by which he "obtains a magnification from ten to one hundred million times." The second is an electric probe by which he reaches layer after layer of a plant or tree from the surface inward.

He has been able to show that the individual cells in the active layer of the cortex expand and contract alternately at intervals of about fourteen seconds in regular sequence from below upward, and so establish a circulation of the sap which in favorable circumstances, may move at the rate of over one hundred feet an hour. These scattered but correlated cells, in their harmonious, aggregate action, fulfil the function of an animal heart.

He is justified in concluding that, "There is, indeed, no characteristic action in the highest animal that has not been

foreshadowed in the simpler life of the plant. Hence, investigations of vegetable life have solved many of the perplexing problems in animal life."

One can even descend still further down in the scale to the bacteria, that is, germs visible only by the microscope. As Welch, of the Johns Hopkins, points out, "The gentle killing of certain bacteria by chloroform enables us to detect in their bodies toxic [poisonous] substances which are destroyed by more violent modes of death."

In the *Atlantic Monthly* for December, 1922, there is a very suggestive article on "The Psychology of Plants" by Clifford H. Farr, Professor of Botany in the University of Iowa. His views are so novel and, one may say startling, that, at my request, he has prepared this short résumé of his paper.

"Mental processes are those which



form part of the experience of one person only' . . . . . You behave in a similar way to me, and . . . . . have the same structure of sense organs, brain, and motor mechanism that I have and, therefore, I conclude that your psychic life is like mine. My contention in this paper, therefore, is that I can demonstrate just as well that the plant has a mind as that you have a mind. Both are matters of analogy of structure and behavior."

The writer then proceeds to describe the sense organ of equilibrium in the root-tip, which is far more efficient than that of the aviator, for keeping the organism properly balanced. Some plants have sense organs of touch, from which impulses are transmitted to motor organs, resulting in movement. There are also sense organs for receiving light stimuli. In addition, the plant is sensitive to temperatures, jar-

ring, pressure, gases, and electrical stimuli, in each case moving in a characteristic manner. The weakest electric current which can be felt by man is 400 times the intensity of the weakest required to cause roots to curve.

It is stated that the opening and closing of leaves in response to light and darkness may be reversed by placing the plant in the light as night and in darkness during the day. "It does not acquire this new habit during the first 24 hours, nor during the second; but gradually within a week completely changes its daily periodicity. In this change of habit, the plant has shown the same reluctance and obstinacy as a man working at the factory in changing from the day to the night shift. The plant also will resume its old habit upon return of normal conditions more quickly than it acquired the new,

displaying what our grandmothers would have called 'backsliding.' "

I show also that plants exhibit memory, the ability to add and subtract intervals of time, and some of their movements may be readily interpreted as expressions of pleasure or pain.

Finally, I present evidence of will power in plants, in selecting the proper chemicals from the soil, in the choice of the temperature at which they grow best, and in turning the leaves to the light and the roots away from it.

## XV.

### EVOLUTION OF RACIAL CULTURE AND CIVILIZATION

XV. So far we have dealt especially with the evolution of man's *physical body*. Professor James K. Breasted of the University of Chicago in his *Ancient Times*, (Ginn and Co.) and later in his brilliant *Hale Lectures* before the National Academy of Sciences (*The Scientific Monthly*, 1919 and 1920) approaches man's evolution from a wholly different angle. He shows that archeological and prehistoric studies have clearly demonstrated a similar progressive *evolution of culture and civilization* of the whole Human Race out of a geological background of prehistoric savagery. He summons to his aid a mass of details and of illustrations which are

most convincing. Read the originals. I cannot condense two volumes into one paragraph.

Man's ascent, from an animal of low intelligence seems to me to be absolutely proved by the many phenomena which reveal identical organs and identical physiological processes in the animal and the human body, only a few of which, chosen out of a very great number, I have described. So too, man's vanishing organs and deformities are allied to what is normal in some of the lower animals. This close relation is confirmed by the discovery of the remains of a number of prehistoric men, as is now definitely proved. The same progress appears in the human race as a whole. The Ascent of Man, in perfectly orderly sequence, is far more probable than that evolution progressed up to the anthropoid

apes and stopped there, and that God then made a man by a separate, special creative act, yet—*mirabile dictu*—with all these minute and exact correspondences of similar structures and functions in animals! Even microscopically, the various structures in man and animals are practically identical. The tiny muscles moving the wings of insects, such as the fly and the mosquito, resemble the muscles of man microscopically.

If man was a special creation, the Almighty was not limited to the lowliest form of matter—the “dust of the ground”—as material for the human body. He could have created a nobler, a more subtile, a more puissant and exalted stuff out of which to fashion man. The plan and structure and function of man’s body would then supposedly have differed *toto coelo* from man’s present body. Probably

it would have been free from the defects and deformities inherent in our animal body, and free from the diseases which it shares with animals.

But no! God deliberately made man out of the *same stuff* as the animals, and, as I have shown, on the *same plan* as animals. Bodywise, man *is* an animal, but, thanks be to God, his *destiny* is *not* the same as that of the beasts that perish. To develop great men, such as Aristotle, Plato, Shakespeare, Milton, Washington, Lincoln, and then by death to quench them in utter oblivion, would be unworthy of Omnipotence. To my mind, it is simply an impossible conclusion. Man's soul *must* be immortal.

Human life is the gradual unfolding of a majestic drama, covering æons of time. In its dawn we see man groping his way towards the light; then slowly, but surely

developing his intellectual life; and finally—how or when we know not now, but doubtless we shall know in the future, in the immortal life—the engrafting by the Creator upon his bodily life of a moral and spiritual life, a soul with a desire to worship, a faculty of adoration and of communion with his Heavenly Father. This wondrous love of God for Man and the final, lofty destiny of the Human Race—this is to me the most impressive, the most inspiring thought of all the ages.

The Poet is often the best interpreter of Truth. His vision is broader and more penetrating than the more prosaic wisdom of the Philosopher or the knowledge of the Scientist. Thus, years ago, sang the Poet Laureate—

“ Flower in the crannied wall,  
 I pluck you out of the crannies,  
 I hold you here, root and all in my hand,



Little flower—but if I could understand  
What you are, root and all, and all in all,  
I should know what God and man is.”

And yet again, with a reverence which  
we do well to imitate—

“ More things are wrought by prayer  
Than this world dreams of . . . . .  
For what are men better than sheep or  
goats  
That nourish a blind life within the  
brain—  
If, knowing God, they lift not hands of  
prayer  
Both for themselves and those that call  
them friends?  
For so the whole round Earth is every  
way  
Bound by gold chains about the feet of  
God.”

(Morte d' Arthur.)











